Very Shallow Water Mine Countermeasures Underwater Breathing Apparatus

A Case Study in Market Research

Summer, 1997

VERY SHALLOW WATER MINE COUNTERMEASURES

1.0 PURPOSE.

This case study provides an illustration of how market research aided in the process of shaping requirements and in streamlining the systems acquisition process for the very shallow water mine countermeasures (VSW MCM) program, a small, yet significant area of naval mine warfare. The case illustrates how mine warfare requirements emerged from basic needs to basic requirements. Ultimately, these requirements are refined during the early stages of an acquisition program and into performance specifications and contracts to deliver products, services and technologies to the fleet. At any level of this evolution, market research is a valuable tool for program managers in translating basic requirements into more definitive requirements. In this case study, a summary of the market investigation efforts for a diver underwater breathing apparatus to meet basic VSW MCM requirements is presented. Clearly, however, market research can and should play an integral role in the acquisition of any product, service or technology.

2.0 BACKGROUND.

2.1 Determining Basic Needs. The National Military Strategy and Navy-Marine Corps White Paper "Forward from the Sea" identified the need to maintain a capability to project power ashore from the sea with amphibious forces. Joint and Naval war-fighting assessments and experiences in Desert Storm highlighted the need to improve our pre-assault Naval mine countermeasure capabilities in the shallow water zones.

2.2 Identifying Capability Deficiencies. Among several operational deficiencies identified were the lack of clandestine mine and minefield reconnaissance capabilities and the lack of "in-stride" clearance capabilities during amphibious operations when advance use of clandestine mine reconnaissance is not tactically feasible. Capability deficiencies in this area were highlighted in various fleet and joint warfare exercises, particularly in the very shallow water (40 ft. to 10 ft. water depth) and surf (10 ft. to shoreline) zones of the water column. Deficiencies were also identified in Commander-in-Chief Integrated Priority Lists. In-service MCM assets were limited in amphibious operations due to their overt and vulnerable nature, their slow clearance rates, and high false-contact rates in shallow water. Current in-service explosive breaching systems in the surf zone mandate that manned assault craft operate from positions off of a hostile beach to launch line charges ahead of the assault waves. These systems were also slow and vulnerable, exposing the personnel and systems to risk of mission failure and possible casualties. The continuing proliferation of anti-invasion mines exacerbates the mine threat.

2.3 Defining Fundamental Requirements. To address these deficiencies, the CNO (N85), the program/resource sponsor for Naval mine warfare, established a Mine Warfare executive committee consisting of, among others, the fleet Mine Warfare

Commander, the Program Executive Office for Mine Warfare, the Chief of Naval Research, leading Naval research and development activities, and others. Included at periodic meetings were other stakeholders such as representatives from the Commanders in Chief, Atlantic and Pacific fleet, the Commander, Naval Doctrine Command, the chairman of the National Defense Industrial Association (NDIA), and others.

2.4 Expanding on Basic Requirements. As the Mine Warfare executive committee continued to meet, initial needs in the area of clandestine reconnaissance and breaching were expanded. Requirements for platforms with multiple sensor suites (*products*) to overcome limitations of single acoustic systems, electro-optical or other sensor systems were identified. The requirement for more precise and robust neutralization systems (*products*) including line and net charge systems were also identified. A mission needs statement was issued highlighting the shortcomings of current systems and identifying the need for clandestine mine reconnaissance and minefield breaching (*products*) capabilities in the very shallow water (VSW) and surf zone (SZ) regions of the water column.. Additionally, requirements for unmanned systems technology (e.g. remote control, autonomous and semi-autonomous systems) for both in-water and airborne systems, and Command, Control, Communications, Computers and Intelligence (C4I) systems for mine countermeasures-to-operational-commander connectivity were identified (*technologies*). Technology was assessed as being mature to proceed into acquisition programs for some of these requirements (*products*). For others, exploratory development and advanced technology demonstrations (*technology*) was needed to determine if systems can be developed to solve the requirements. Continuing fiscal constraints lead to requirements for additional studies and analyses (*services*) to aid in determining the right mix in force structure, and to assist in making the best investment decisions for near-, mid- and far-term requirements. Assessments further emphasized the need to reduce reliance solely on fly-away, dedicated MCM systems, and transition at least part of our MCM capability to the deploying fleet was identified. A CNO/CMC white paper identified the need to "mainstream" mine warfare, by fielding MCM systems (*products*) and capabilities which are "organic" to the deployed battle groups. Near-, mid-and far-term requirements was prioritized by the program sponsor through the executive committee process, and program plans were developed. The Naval Mine Warfare Plan was published highlighting in-service MCM systems and the basic concept for their employment in support of Naval and Joint doctrine. Investment plans were delineated in the form of Near-, mid-, and far-term acquisition and technology programs.

2.5 VSW MCM Requirements. Included in the FY96 Naval Mine Warfare Plan were capability deficiencies in advance force, Very Shallow Water Mine Countermeasures operations. Assessments and studies cited the lack of near-term technology solutions for unmanned systems, noting that better equipped and trained divers offer one of the more feasible near term solutions to long-standing capability deficiencies. Diver performance during exercises and in Desert Storm identified several basic equipment and training requirements which prevented adhoc diver forces from effectively accomplishing the VSW

MCM mission. In early FY96, CNO (N85), in concert with the Commander, Mine Warfare Command (COMINEWARCOM), authorized establishment of a VSW MCM Test Detachment to address this continuing capability deficiency. Program management responsibility was assigned to the EOD Program Manager (PMS-EOD) under the PEO Mine Warfare (Naval Sea Systems Command). A small cadre of Navy EOD, SEAL, and US Marine Corps RECON personnel, having expertise in similar tasks were assigned to the test detachment under the EOD Group at NAB Coronado, CA within the Pacific Fleet. Their task was to work with PMS-EOD to evaluate tactics, techniques and procedures along with prototype equipment for use in the VSW MCM task, with a goal of fielding an initial core contingency capability by the end of FY99. An Integrated Product Team (IPT) was formed by the EOD Program Manager with VSW Test Detachment personnel (the fleet owners of the problem) participation. A comprehensive review of lessons learned, assessments, and detailed discussions with the users resulted in identification of the following basic diver system requirements for overcoming capability deficiencies with in-service systems:

- VSW MCM Underwater Breathing Apparatus (UBA) set
- Diver-held Underwater Precise Navigation set
- Diver-held portable sonar system
- Dive Suits/Thermal Protection gear
- Diver Propulsion Vehicle
- Diver Communication system

3.0 MARKET SURVEILLANCE

Beginning in November 1995, the commercial market was surveyed to determine the availability of equipment to meet near-term Very Shallow Water Mine Countermeasures (VSW MCM) systems requirements for divers in the mine reconnaissance task. To support the need to rapidly field an initial VSW MCM capability, surveillance efforts were focused on locating potential, commercial-off-the-shelf (COTS) equipment or alternatively, equipment which might be made suitable for the VSW MCM task with only slight modification for each of the system requirements identified in the preceding paragraph.

IPT members conducted Urgent Data Requests (UDR) to gather information from public sector laboratories and universities. A Commerce Business Daily (CBD) ‘sources sought’ announcement was published to solicit potential commercial products. On-line sources of product information were searched using the Internet, and trade publications were scoured for relevant products and potential vendors. ‘Cold Calls’ to potential vendors were used in many cases to explain unique VSW MCM concerns and to solicit additional product information.

In some cases, meetings with vendors with potential candidate systems were conducted to get a better understanding of the systems capabilities and limitations. Representatives of the VSW MCM Test Detachment - the fleet "end user" participated in these meetings. Equipment requirements from the list above were prioritized in terms of potential market maturity against the estimated requirements, and their potential for improving operational capabilities in the VSW mission. In areas where commercial markets were determined to exist, more comprehensive, follow-on investigations continued over the next 18 months, with the VSW MCM Test Detachment and EOD Program office engaged in field-testing of prototypes. In areas where commercial markets offered no potential hardware solutions, requirements were passed to research and development activities for inclusion in exploratory or advanced technology programs.

3.1 VSW MCM Underwater Breathing Apparatus (UBA). The remainder of this case study focuses on market surveillance and investigation efforts related to addressing the UBA requirement. A review of previous assessments and extensive discussions with fleet operators resulted in identification of key limitations of Navy "in-service" UBA sets.

3.1.1 Understanding Current Limitations. In the 1970's, prior to acquisition of more specialized UBA systems designed for primary (non-VSW) missions, both U.S. Navy EOD and SEAL teams used early predecessors to modern-day, semi-closed circuit UBA systems used most predominantly by allied MCM divers. Semi-closed systems maintain a constant flow of gas to the diver with sufficient oxygen to meet the diver's oxygen demand. While most of the gas is re-cycled and enriched with sufficient oxygen to sustain an adequate breathing supply, they do "off gas" a small amount of gas during operation. In-service U.S. Navy systems deemed most suitable to the VSW MCM task today include "closed-circuit" re-breathers designed for other (non-VSW MCM tasks). The following discussion elaborates on key limitations of U.S. Navy rigs in the VSW task:

- **MK 16 UBA (EOD Mine Countermeasures UBA system).** The MK 16 is a closed circuit rebreather at operating depth, designed for EOD re-acquisition of previously detected mines. This system is relatively large, and uses an electronic system to monitor and adjust the diver's gas mixture to maintain a constant partial pressure of oxygen at depths from sea level to 190 feet. Because of its size, the rig is not well-suited for long swims typical in search profiles of the VSW MCM mission. Additionally, as the diver ascends, the rig "off-gasses" to accommodate the increased volume with decreasing pressure. This aspect is not acceptable for VSW MCM operations in near shore areas where hostile forces could easily detect the presence of vulnerable VSW MCM forces. Low-influence signature characteristics of the MK 16 are positive aspects of the rig in mine reconnaissance roles.

- **LAR 5 MOD I (Navy Seal and USMC Reconnaissance Combat Swimmer UBA system).** Unlike the MK 16 UBA, the LAR V was designed for use in shallow water. It is intended as a rapid insertion/extraction UBA for combat swimmer forces and is well suited to hydrographic reconnaissance missions typical of the VSW MCM task. Unfortunately, the LAR V is a closed circuit oxygen rebreather, suitable for use as a search rig from 21 feet of sea water (fsw) and shallower due to the risk of oxygen toxicity when operating at depths greater than 21 fsw. The VSW MCM requirement extends out to the 40 foot depth curve. Recent modifications to the LAR V set have resulted in lower magnetic signatures which make it suitable for use in a mine field.

3.1.2 Identifying Key Requirements. A careful assessment of in-service allied UBA systems (semi-closed) revealed that while more suitable for meeting the depth and hydrodynamic (size) requirements of the VSW MCM task, they were deficient in meeting estimated rig duration and influence signature requirements. The IPT concluded that semi-closed UBA systems offered a more viable approach to overcoming "off-gassing" and O_2 toxicity limitations inherent in the MK 16 and LAR V closed circuit systems when used for the VSW MCM task. They concluded that slight modifications to available semi-closed systems could potentially solve rig duration and influence signature requirements and offer significant improvement over in-service U.S. Navy UBA systems in the VSW task.

3.1.3 Understanding the Market. UBA market surveillance efforts also revealed that the "re-breather" market for recreation diving was expanding, and that several companies had semi-closed UBA products either in development, or already available for sport divers. The IPT learned that companies which produce life support systems for both underwater and land applications had a great deal of expertise in manufacturing UBA rigs for both U.S. and allied military organizations, as well as commercial markets, and that several potential candidates could be made available for evaluation as VSW MCM UBA prototypes with very short lead times.

4.0 VSW MCM UBA MARKET INVESTIGATIONS.

Once it was determined that the commercial market offered potential solutions to the VSW MCM UBA system requirement, an equipment matrix was constructed to compile the performance characteristics into a digest for comparison of product alternatives. Shown in Table 1 is a summary of some of the key characteristics of commercially available alternatives against the in-service EOD and Navy SEAL UBA sets. The matrix enabled the IPT to understand the performance potential of commercial UBA systems versus both known performance parameters of in-service systems, and estimated performance requirements for the VSW MCM mission given daily tactics training in the

local San Diego operating area with in-service UBA sets. From these, and follow-up vendor meetings, candidates deemed most suitable to enhance detachment capabilities over the in-service systems were leased from the applicable vendors.

A small sample of systems determined to have the potential for improving VSW MCM diver capabilities was leased and provided to the Naval Experimental Diving Unit (NEDU) at Panama City, FL to conduct preliminary manned and unmanned safety tests prior to use by the VSW Test Detachment in their local training environment. Members of the VSW MCM Test Detachment participated in manned testing phases at NEDU to gain an initial orientation on the specifics of the rigs in a controlled environment. If candidates successfully made it through the NEDU tests, a larger quantity of prototypes were leased by the program office, waivers were granted by the CNO for evaluation in the local VSW Test Detachment training area, and all detachment members were provided classroom and swimming pool orientation training on the prototype rigs.

Table 1. VSW MCM UBA Market Investigation Summary

MARKET INVESTIGATION SUMMARY VSW MCM UBA	CASE DIMENSIONAL VOLUME (m^3)	Weight in air (kg)	Non-magnetic (STANAG 1097)?	Non-magnetic (MIL-M 19595C)?	Operating Tamp Range (deg C)	Operating Duration (minutes)	Max Depth (meters)	Unit Procurement Cost est. (for 50 rigs)	Unit Cost for 3 evaluation units	Availability Date for Eval Units	Availability Date production units
	RIG SIZE		INFLUENCE SIGNATURE		OPERATIONAL ENVIRONMENT			SUPPLIER INFORMATION			
In-service Kit I (MK 16)	.059 m^3	29	Yes	Yes	-2° to 33°	200	91	N/A	N/A	N/A	N/A
In-service Kit II LAR V/I	.022 m^3	15	Yes	Yes	1° to 35°	90-100	6.4	N/A	N/A	N/A	N/A
Company A Product Z	.022 m^3	15	Yes	No	1° to 35°	140	23	$12K	$12K	NOW	6-9
Company A Product Y	.034 m^3	16.4	No	No	1° to 35°	140	23	$10.2K	$10K	<6	6
Company A Product X	.069 m^3	35	Yes	No	1° to 35°	125	90	?	?	?	?
Company A Product W	.045 m^3	17.5	Yes	No	1° to 35°	170	23	?	?	?	?
Company B Product U	.033 m^3	14.5	No	No	?	?	6	?	?	?	?
Company B Product T	.068 m^3	35	No	No	-2° to33°	120	57	$27K	$5K	NOW	12
Company C Product S	.023 m^3	11.6	No	No	?	?	6	$35K	$20K	?	?
Company C Product R	.045 m^3	23	No	No	-2° to 33°	210	55	$13K	$39K	<6mos	6
Company D Product Q	.038 m^3	25.5	No	No	0° to 43°	360	152	$15K	?	<6mos	?
Company E Product P	.031 m^3	18.2	No	No	-2° to 33°	280	45	?	?	<6mos	12
Company F Product N	.036 m^3	25	Likely	No		240	160	$22K	$10K	<1mo.	?
Company G Product M	.022 m^3	14	Yes	No	-2° to 40°	170	24	$7.7K	$3K	NOW	6
Estimated Requirement	<MK 16	<MK 16	Yes	Yes	TBD	>180	>12.5	N/A	N/A	N/A	N/A
Refined Requirement	.051	27.3	Yes	Yes	-2° to 35°	>240	>18.3	N/A	N/A	N/A	N/A

Prototype rigs were then used in the local training area and evaluated for potential as a detachment system. Recognizing that the projected VSW operating environment varies in different coastal areas, a training range was selected in the local San Diego area which was characterized as a moderately harsh VSW operating environment. Over an 18 month period, the detachment conducted several tactical training sessions with both in-service equipment and operational prototypes.

With the lease of each UBA candidate that successfully completed NEDU testing, the EOD Program Office delivered prototypes with evaluation forms designed to assess the suitability of the equipment against the estimated requirement. Periodically, to ensure that equipment evaluations were not merely limited to one environment, the Test Detachment participated in Fleet and Joint exercises. Since establishment, they have mobilized to other areas (e.g. North Carolina, Camp Pendelton and Australia) to evaluate tactics and prototype equipment in other environments.

From equipment evaluations, the Test Detachment concluded that commercial systems offer great potential for improving diver capabilities in the VSW MCM task over in-service UBA systems. Prototype evaluations have enabled the fleet to validate specific requirements, which have been incorporated into requirements documents. Additionally, evaluations have resulted in reduced technical, schedule and cost risk associated with the pending acquisition of the fleet VSW MCM UBA systems.

The bottom two rows of table 1 present a comparison of the estimated requirements at the beginning of the market investigation along with the resulting requirements which are in the requirements documentation. Through the prototype evaluations of commercial systems, the IPT members (end-users and acquisition personnel) were able to better define system requirements in a manner which addressed both fleet needs and acquisition/life cycle support. Aside from key performance requirements tabulated in Table 1, additional requirements emerged through the market investigation and prototype evaluation process. Some of these are illustrated below:

- Gages visible in low-light/no-light
- 1-hand release ditching capability of system
- Controls workable with gloved-divers in cold water
- 60-minutes between rig set-up and use capability
- Interface with Navy charging hardware
- Storage temperatures from -29^{o} to $60^{o}C$
- Non-gloss black coloring
- Accessible O_2 components for cleaning
- CO_2 level and breathing resistance parameters
- CO_2 scrubber performance requirements

5.0 CONCLUSION

Due to influence signature and diver duration requirements (see table above) unique to the VSW MCM mission, there is no known commercial (or military) diving system which is suitable off-of-the-shelf as a VSW MCM UBA. Several products however could meet the fleet VSW MCM UBA requirements with only slight modification. Once a system is acquired, there are potential expanded applications in other areas both within the U.S. Navy, USSOCOM, and in allied MCM diver forces. Commercial markets may also emerge from the VSW MCM acquisition project. A draft performance specification was developed, incorporating requirements defined and validated by the fleet. PEO Mine Warfare recently approved an abbreviated acquisition program for streamlined acquisition of the VSW MCM UBA system. A competitive procurement strategy is anticipated for this program, and several vendors appear interested.